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ABANDONED MOUNTAIN PINE BEETLE GALLERIES IN LODGEPOLE PINE

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ABSTRACT

During the fall of 1974, 129 galleries of the mountain pine beetle (Dendroctonus ponderosae *Hopkins) in 32 recently attacked lodgepole pines* (Pinus contorta *var.* latifolia *Engelmann) were examined to determine incidence of "pitching out." With one possible exception, galleries containing no females (33 percent) had been abandoned; females had not been pitched out. Small trees generally had a higher proportion of abandoned galleries, and these were usually longer than those in large trees. Low occurrence of males, which probably resulted in low incidence of fertilization in the attacking population on individual trees, is believed to be the factor responsible for gallery abandonment. Fertilized females constructed galleries and oviposited regardless of attack density.*

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Pitch tubes caused by the mountain pine beetle (*Dendroctonus ponderosae* Hopkins) attempting to infest lodgepole pine (*Pinus contorta* var. *latifolia* Engelmann) are common and can persist for years. Trees on which they are found are said to have "pitched out" beetles. Resin ducts are severed when the female starts construction of her egg gallery. If profuse enough, resin from these ducts forces the beetle from the gallery or the pitch kills her. Observations reported here indicate that in most cases females are not pitched out; instead, they apparently abandon galleries because they have not been fertilized.

METHODS

A total of 129 galleries on 32 newly infested trees were examined on three National Forests--Wasatch in northern Utah; Bridger-Teton in northwest Wyoming; and Targhee in southeast Idaho--in August 1974, 1 to 3 weeks after the beetle's flight period began. Trees were arbitrarily selected; therefore, data are not representative of the entire beetle population.

Galleries within a 6-inch-square area of bark were opened on each tree that received a full attack by the beetles. The lower 6 feet averaged two or more attacks per 6-inch area. These trees will die as a result of attacks. On lightly infested trees, all galleries were opened irrespective of bark area. Such trees had only one to five galleries on the lower 6 feet of the bole. These trees will not die as a result of attacks. The lower bole of lodgepole pine was examined because it is usually infested first by the mountain pine beetle (Rasmussen 1974).

Data recorded from each gallery were: (1) length of gallery; (2) female, present or absent; (3) male, present or absent; (4) eggs, present or absent; and (5) beetles entangled in the pitch tube or pitch in the gallery. When two beetles were in the same gallery, one was considered to be male; where no male was found but eggs were present, it was assumed the male left the gallery after fertilizing the female. This assumption seems reasonable because McCambridge (1970) observed that less than 2 percent of the new females are fertilized prior to emergence and attack.

In addition to the 1974 attacks, galleries from old attacks that occurred one or more years before were examined on 12 trees that were still alive.

RESULTS AND DISCUSSION

Results are largely from the Wasatch National Forest, where about 75 percent of the observations were made. In addition, these observations were made about 3 weeks after the flight period commenced; so little change would be expected in the number of attacking females being fertilized and laying eggs.

Examinations indicated that beetles were not "pitched out." Instead, apparently, 33 percent of the galleries were abandoned by females when they were not fertilized. An additional 10 percent of the galleries contained females, but no males nor eggs. These were potential cases for abandonment.

Pitch tubes at the entrances of galleries where females are actively boring are reddish because of frass in the pitch. After the female stops boring (apparently because fertilization has not occurred), she continues to keep the gallery free of pitch by pushing it out the entrance (see Blackman (1931) for an excellent description of this behavior). The pitch tube becomes cream colored when only pitch is pushed from the entrance. Further, it continues to increase in size as long as the unfertilized female keeps the entrance open.

Unfertilized females extended galleries to 2.2 inches; they abandoned the galleries if mating did not occur by then. Rasmussen (1974) reported that the unfertilized female makes about 2 inches of egg gallery in 8 days. Therefore, it would appear that a female will wait up to 9 days before abandoning the gallery. I found that abandoned galleries averaged 0.95 inch in length (N=42; SD=0.63); so, based on Rasmussen's (1974) observations of gallery construction by unfertilized females, the number of days before abandonment would average about four.

Lengths of abandoned galleries were usually longer in small diameter trees (fig. 1). Abandoned galleries averaged slightly more than 1 inch long in trees 9 inches d.b.h. and less, except the two 0.25-inch galleries in the tree 5 inches d.b.h. However, in trees 12 inches d.b.h. and larger, abandoned galleries averaged about 0.5 inch. In addition, the proportion of galleries abandoned was greater in small trees, ranging from 100 percent in the tree 5 inches d.b.h. to 20 percent in trees 12 inches d.b.h. (fig. 2).

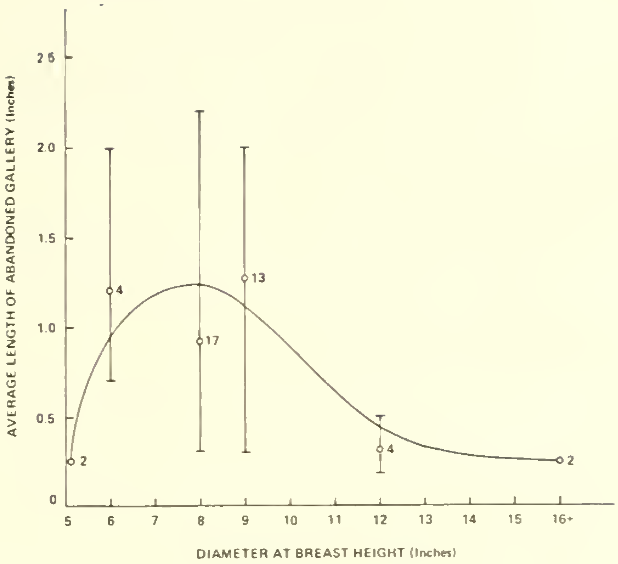

Figure 1.--Length of abandoned galleries for trees having different diameters at breast height. Data were taken from the Wasatch National Forest. Number by data point represents number of abandoned galleries examined. Vertical lines indicate ranges in observations; all galleries in 5- and 16-inch trees were 0.25 inch long.

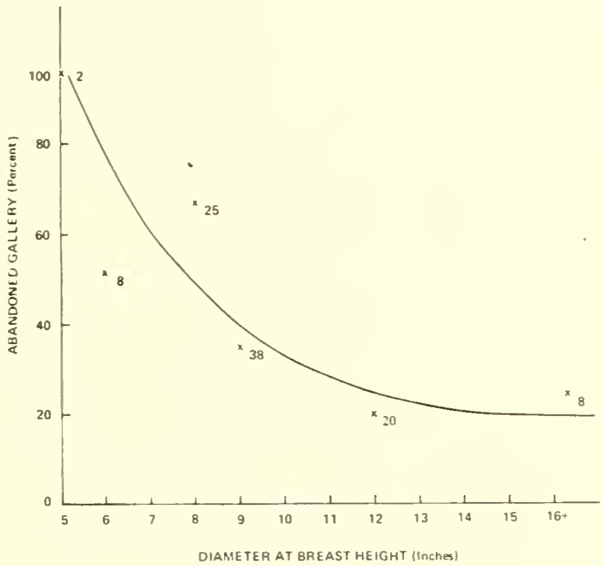

Figure 2. Percent of abandoned galleries for trees having different diameters at breast height. Data were taken from the Wasatch National Forest. Number by data point represents total number of galleries examined.

A possible explanation may lie in pheromone production. Most of the small trees were not fully attacked; so antiaggregative pheromone concentration (Rudinsky and others 1974) probably was low and unmated females might continue gallery construction while waiting for males. However, most large diameter trees were fully infested and concentration of antiaggregative pheromone could be expected to be high. Hence, females that were just starting egg galleries might leave in response to high antiaggregative pheromone concentration. Beetles that abandoned galleries probably flew to newly infested trees and constructed egg galleries in uninfested portions of the bark.

Pitch tubes and galleries, one to several years old, were examined in previously attacked, but living, trees. Galleries were up to 2 inches in length and resin filled. Areas in the bark over the galleries were necrotic. In some cases, phloem and xylem had almost grown over some old galleries. These galleries probably were constructed by unfertilized females also.

Only one dead female was found in a pitch tube resulting from 1974 attacks. No beetles died within the galleries indicating that "pitching out" as a result of tree response does not appear to be an accurate explanation for empty galleries. "Abandoned tree" would be a better term in most cases. Although true "pitching out" may occur, it appears to be much less common than previously thought.

Tree killing results when an adequate number of females and males are present in suitable ratio. I found that of the galleries examined on trees expected to die from the attack, 33 percent contained males and 78 percent contained eggs. In contrast, examinations of galleries in trees that would not be expected to die from the attack showed only 8 percent contained males and 43 percent contained eggs. The mountain pine beetle population in lodgepole pine almost always has a sex ratio that favors females. Reid (1958) found during a 3-year study that females constituted 67 to 70 percent of the population. The population that Rasmussen (1974) studied was 74 percent female. Sex ratios of attacking populations on individual trees could deviate considerably from these figures.

Unpublished data (Intermountain Forest and Range Experiment Station, Ogden, Utah) show that on the average small trees produce a greater proportion of females than large trees. Consequently, the shift of the attacking beetle population to smaller diameters toward the end of an infestation (Cole and Amman 1969) could increase the proportion of females in the population and the incidence of abandoned galleries. Both crowding (Cole 1973) and drying of bark (Amman and Rasmussen 1974) are involved in reduced male survival.

In the study reported here, the sample showed that most males abandoned the gallery soon after fertilizing the female. Males were found in only 16 percent of the galleries. Forty-one percent of the galleries had eggs but no males present. Galleries in which both males and eggs were present usually were longer ($N=10$); $\bar{X}=6.2$ inches; $SD=2.87$ inches) than those where eggs but no males were present ($N=46$; $\bar{X}=4.59$ inches; $SD=2.47$ inches). This difference may be related to the male's help in keeping the gallery free of boring frass by pushing it out of or into the base of the gallery (Reid 1958). Consequently, the female has more time for gallery boring and egg laying.

Of special significance is the fact that fertilized females constructed galleries regardless of attack densities--even when but one beetle attacked a tree. For example, a single female attacked a tree 7 inches d.b.h. and had constructed about 7 inches of gallery when the bark was examined. Eggs had been laid throughout the length of the gallery; however, heavy resin soaking occurred similar to that described by Reid and others (1967). In my study, this phenomenon was observed only in lightly attacked trees. Resin would prevent eggs from hatching, as was demonstrated experimentally by Reid and Gates (1970).

The fact that females continued to construct galleries and to lay eggs when only a few beetles attacked a tree strongly indicates that most successful attacks (those that result in gallery construction and oviposition) depend upon fertilization of the female. Success in terms of brood survival depends upon adequate attack and gallery densities that would prevent resin soaking of galleries and eggs.

Observations are needed to determine the extent of gallery abandonment and "pitching out" on a population basis. In addition, studies are needed to determine why males apparently respond more positively to some trees than to others under attack.

Production of the aggregative pheromone, *trans*-verbenol (Pitman and others 1968), may be one reason for positive response. Hughes (1973) reported that the presence of α-pinene initiated or increased biosynthesis of *trans*-verbenol by the beetle. Alpha-pinene was found to range between 2 and 50 percent of the terpene fraction of oleoresin in 11 lodgepole pines sampled in Montana (Lotan and Joye 1970); between 0.7 and 5.5 percent in five trees sampled in Canada (Shrimpton 1974); and between 5.0 and 7.4 percent in 10 trees sampled in California (Smith 1964). Other chemicals contained within the bark might also influence pheromone production (Vité and Pitman 1967).

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